NUMERICAL INVESTIGATION ON STEEL – CONCRETE COMPOSITE SLABS UNDER BLAST LOADING

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRACT

This paper discusses the numerical investigation on steel – concrete composite slabs under blast loading. The study was conducted using finite element software and the finite element model of the steel – concrete composite slabs was validated against a disparate test data. The model was used to investigate key parameter in particular; the diameter of mesh reinforcement used in the steel – concrete composite slabs. The validation results show that the computed model of steel – concrete composite slabs can almost replicate the result from the experimental. Thus, the model that have been computed was extended for blast simulation using CONWEP. CONWEP is a blast load function available in Abaqus FEA. The blast-profiles from the CONWEP was verified against the result obtained from a disparate field test. The results suggest the CONWEP is able to simulate the blast-pressure profiles with sufficient accuracy. By using CONWEP in Abaqus, the validate composite slabs were subjected to various blast loading cases. From the study, it was found that the pressure is affected by the stand-off distance and the weight of the mass explosive. Which the higher the explosive mass and the shorter standoff distance used will produce high impulse. High impulse load resulted a higher displacement on the steel – concrete composite slabs. Finally, from the parametric study, the limit diameter mesh reinforcement to use in steel – concrete composite slabs is 8 mm because increasing it more will not give significant resistance toward blast load.

ABSTRAK

Kertas kerja ini membincangkan tentang kaji selidik mengenai lantai komposit keluli – konkrit apabila terkena bebanan letupan. Kajian ini telah dijalankan menggunakan perisian komputer Abaqus. Model lantai koposit keluli – konkrit yang direka melalui perisian komputer ini telah disahkan melalui beberapa pengesahan data daripada ujian-ujian yang berbeza. Model yang sama juga telah digunakan untuk mengkaji parameter yang lain seperti kesan penukaran saiz diameter tulang kerangka yang digunakan dalam struktur lantai komposit ini. Hasil keputusan telah mengesahan bahawa model yang komputer yang direka mampu menghasilkan keputusan ujian yang hampir sama dengan hasil keputusan ujian daripada ujikasi ekperimen. Oleh itu, model ini akan dilanjutkan lagi untuk ujian simulasi letupan menggunakan fungsi "CONWEP" yang tersedia di dalam perisan Abaqus. Sebelum itu, satu pengesahan lain telah juga dilakukan, iaitu simulasi ujian letupan ke atas rasuk keluli yang berdasarkan dari kesusasteraan yang lain. Dari pengesahan itu, satu kesimpulan dibuat bahawa tekanan dari letupn dipengaruhi oleh jarak dan berat bahan letupan. Ini bermaknsa, lebih tinggi jisim bahan letupan dan jarak antara tempat letupan dan struktur pula adalah pendek, maka satu bebanan yang tinggi akan terhasil. Dari simulasi yang dilakukan, bebanan yang tinggi akan menyebabkan kerosakan yang tinggi. Akhir sekali, dari kajian parameter yang telah diadakan, saiz diameter maksima yang disyorkan untuk tulang kerangka untuk digunakan adalah 8 mm. Hal ini kerana, jika saiz diameter lebih tinggi digunakan, ianya tidak akan memberi kesan yang signifikan terhadap rintangan daripada bebanan letupan.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Steel – concrete composite slabs means that there are at least two components of the structure such as the steel deck and reinforced concrete floor that is bonding together by any mechanical techniques and act compositely to resist the tension and compression of the structure when subjected to any loads. Other than that, this type of structure can give advantages when comes to faster flooring construction, lighter floors and the rational use of construction materials (Marimuthu V., Seetharaman S., et al., 2006). Thus because of all that, this structure is becoming more popular in nowadays construction industry.

As it becomes common in buildings, researchers are interested to investigate the behaviour of the structures to blast loads because of the threats from terrorist attacks are ever increasing. Recently, Sri Lanka, had experienced three bombing incidents that resulted in more than 300 casualties and severe damages to buildings. Therefore, it is evident there is a need to investigate the response of the composite structure such as steel-concrete composite slabs to improve the understanding of the behaviour of the structure when subjected to blast loading.

Other evident is when Jintao Li and others (Jintao Li., Chao Huang, et al., 2018) conducted detailed finite element analysis of composite bridge deck to study the behaviour of structure under blast loading. The result suggested that the damage modes of the structure are depend to the type of the loading subjected which the high impacts loads are difference with blast loads. Thus, to ensure the safety of these structures especially for construction of blast-risk structures such as embassy buildings, it is important to design them which can withstand the expected design-based threat level.

1.2 Statement of Problem

There is no literature can be found for the steel – concrete composite slabs subjected to the blast loading. Most of them, focussed on the experimental of the steel – concrete composite slabs under high impacts loading rather than the blast loading. For example, an experimental study has been carried out to investigate primarily the shear bond behaviour of the embossed composite deck slabs under simulated imposed loads, from paper by Marimuthu, Seetharaman, et al. (Marimuthu V., Seetharaman S., et al., 2006) and behaviour of headed shear stud in composite beams with profiled metal decking from paper by Qureshi and Lam (Qureshi J. and Lam D., 2012). This is because the experimental on the blast loading is too costly and high risk.

As the alternative to experimental methods, the numerical model can be performed using finite element software such as Abaqus FEA. This method can quantitatively stimulate the mechanical character of the steel – concrete composite slabs subjected to blast loading in more flexible and cheaper way. By utilise the finite element analysis, the understanding on the performance and response this structure under blast load can be enhance. Furthermore, parametric study can also perform to study the effect of that parameters to help improve the blast resistance design consideration for this structure in the future.

1.3 Objective of Study

In general, the objectives of the study are;

a) To model steel-concrete composite profiled slab using Abaqus FEA software and validate the model against test data.

b) To study behaviour of steel-concrete composite slabs under the blast loading.

c) To study the influence of reinforcement mesh diameters on the behaviour of the steel-concrete composite slabs subjected to blast load.

1.4 Significance of Study

This paper studies about the response behaviour of steel – concrete composite slabs under blast load. Thus, from that result and data from the numerical analysis of the structure, we can develop some awareness of the hazards and risks created by the blast loads. For future use, this paper can help in other researchers to implement the blast resistance design of the structure especially in steel – concrete composite slabs to prevent structure failure.

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